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Protocluster Survey at z = 2.23: from Herschel to ALMA

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Abstract. We present results of *Herschel*/SPIRE observation in 2QZ cluster at z = 2.23. 2QZ cluster is discovered as an overdensity of QSOs and Hα emitters (HAEs), which was originally identified as a concentration of 5 QSOs in the 2dF Quasar Redshift survey. We find an overdensity of SPIRE color selected far-infrared bright galaxies (3.9 σ compared with COSMOS field) $\sim$5′ west of the HAEs density peak of in a radius of 6 co-Mpc. This suggests 2QZ cluster is experiencing enhanced dusty star-formation. However, SPIRE color selection with S_{500}/S_{350} vs S_{350}/S_{250} has a redshift uncertainty, we need spectroscopic observation with ALMA to confirm the precise redshifts.

1. Introduction, Observation, and Analysis

Since $z < 1.5$ cluster cores are experiencing quench star-formation (Brodwin et al. 2013), the key star-formation phase with dusty starburst (Casey et al. 2014) appears to have occurred at $z > 2$. Because QSOs tend to be the most massive galaxies at any epoch of the universe and located in centers of largest-scale structures, a very good target is 2QZ cluster, which contains 4 QSOs and overdensity of 22 HAEs including 3 HAEs-AGNs in 400 co-Mpc^2 at z = 2.23 (Matsuda et al. 2011, Lehmer et al. 2013).

Our observations were performed as part of the second Open Time *Herschel* programs (PI: Y. Matsuda). The coverage of the maps are $20' \times 20'$ and an integration time is 1.8 hours. The typical instrumental noise is $\sim$ 3.0 mJy in each SPIRE bands.

We detect sources in the 250 μm image within regions with relative coverage greater than 30 %, and then conduct 350 μm and 500 μm photometry. We create source catalogue which at least one SPIRE band flux is above 12 mJy. The number counts of 250, 350 and 500 μm are almost consistent with Béthermin et al. (2012) and slightly excess is found at 500 μm wavelength. We apply S_{500}/S_{250} vs S_{500}/S_{350} color selection which is consistent with grey body SED (T_d = 30 − 40 K, β=1.5) at z = 2.23. We include a photometric color error of ± 20 %. We calculate the $L_{\rm FIR}$ by fitting the flux of the 3 SPIRE bands, and investigate the sky distribution with $L_{\rm FIR} > 5.0 \times 10^{12}\ L_{\odot}$.

2. Results and Discussion

We find 3.0 times overdensity of 6 selected bright SPIRE sources ∼5′ west of the HAEs density peak in a radius of 6 co-Mpc. This radius is typical scale of far-infrared overdensities (Rigby et al. 2014). We note one of them shows the $L_{\rm FIR} > 10^{13}\ L_{\odot}$. These results suggest 2QZ cluster could be experiencing both enhanced dusty star-formation and AGNs activities. However, SPIRE color selection has a redshift uncertainty. Although we cut ∼90 % sources with color selection and luminosity limit, we need spectroscopic observation with ALMA to test the enhanced dusty star-formation activity with precise redshift.

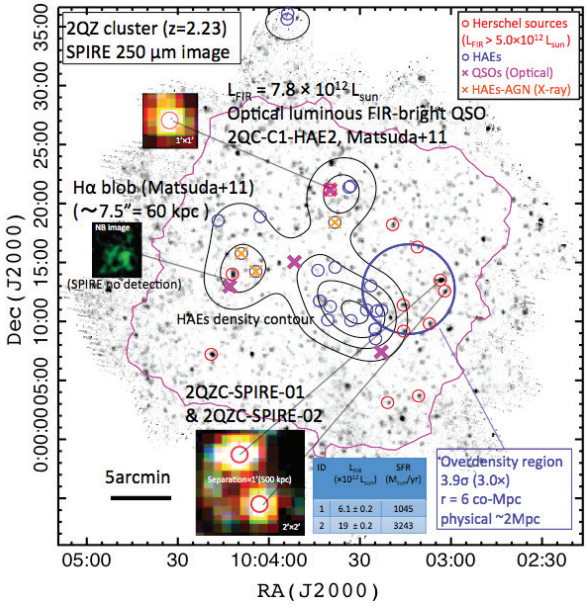

Figure 1. Sky distributions of galaxies in 2QZ cluster. We find 3.9 σ overdensity of 6 SPIRE sources, suggests that 2QZ cluster could be experiencing both enhanced dusty star-formation and AGNs activities.

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References

Béthermin M., et al., 2012, A&A, 542, AA58
Brodwin M., et al., 2013, ApJ, 779, 138
Casey C. M., Narayanan D., Cooray A., 2014, PhR, 541, 45
Lehmer B. D., et al., 2013, ApJ, 765, 87
Matsuda Y., et al., 2011, MNRAS, 416, 2041
Rigby E. E., et al., 2014, MNRAS, 437, 1882